my radiotherapy book

Information to help you understand the treatment

Edition 2: April 2019

brainstrust
the brain cancer people

Clinical and Translational Radiotherapy
Research Working Group

Thornbury
Gamma Knife Centre

Contents

Introduction

Having a brain tumour is complex. Treating a brain tumour is complex. Today, clinicians no longer treat just plain cancer; they use the knowledge of the biology of cancer to plan treatments more effectively, as they know so much more about it. They know much more about which cancers may respond to specific treatments, and which won't. And this includes radiotherapy (sometimes referred to as radiation therapy) treatments. Treatments are personalised to match each patient's needs. Technological developments mean that there are several options about which is the best radiotherapy treatment to be offered. Some treatments will be inappropriate, so it is a question of finding which treatment is the best option. It is not that one treatment is better than another but which is the most appropriate treatment for the patient.

This leaflet is to help you understand the range of radiotherapy treatments that are currently available so that you know and understand what would be the appropriate and best treatment for the type of brain tumour you are living with, whether you are a carer or a patient. We know how confusing it can be, give *brainstrust* a call if you want to talk it through: 01983 292 405 or drop us an email at hq@brainstrust.org.uk

How a brain tumour is treated

The current options for treating a brain tumour include surgery, radiotherapy, and chemotherapy, or sometimes what is called active surveillance, which means watching and checking at regular intervals. Many people have a combination of treatments and the choice of treatment depends mainly on the following:

- The type and grade of brain tumour
- Its location in the brain
- Its size

- Age of the patient
- General health

Cancer therapy often damages healthy cells and tissue and therefore side effects are common. Before treatment starts, ask your health care team, which will include your oncologist, clinical nurse specialist and radiographers about possible side effects and how treatment may change your normal activities.

These are things you may want to ask before you begin treatment:

- What are my treatment choices? Are there any choices available elsewhere that aren't available here?
- Which do you recommend for me? Why? How does that treatment work?
- What are the expected benefits of each kind of treatment?
- What can I do to prepare for treatment?
- Will I need to stay in the hospital? If so, for how long?
- What are the risks and possible side effects of my treatment? How can side effects be managed?
- How will treatment affect my normal activities? What is the chance that I will have to learn how to walk, speak, read, or write after treatment?
- Would a research study (clinical trial) be appropriate for me? If it isn't, why not?
- I might decide to seek a second opinion. What would the questions be that you would ask?

There are two categories of brain tumours in cancer: primary (the cancer starts in the brain) and secondary (where the cancer has spread from another part of the body). Primary cancer is usually treated with radiotherapy, whereas secondary tumours, which are usually smaller, deep seated and in many cases multiple, are often better treated with radiosurgery.

Radiotherapy

What is it?

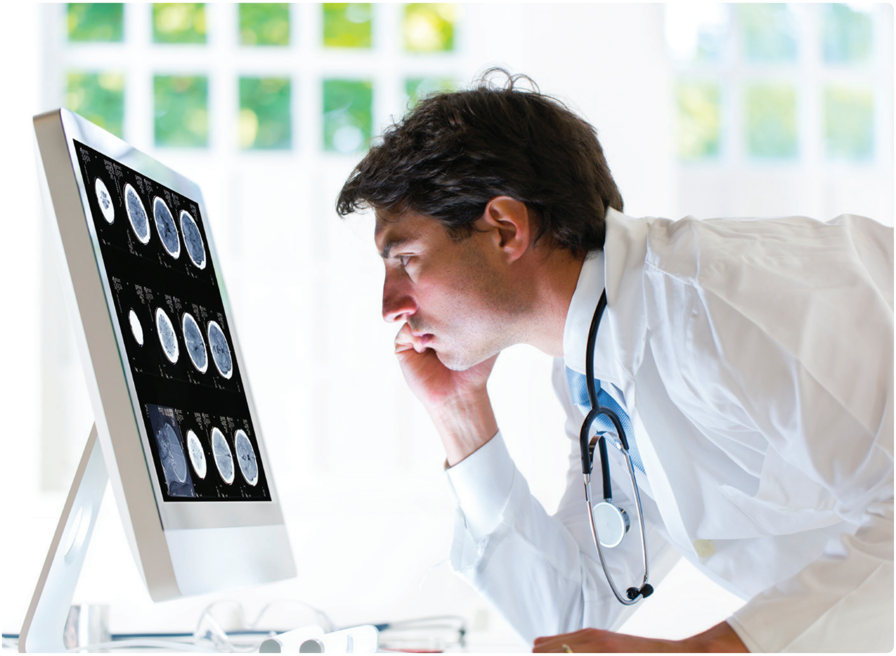
Radiotherapy kills brain tumour cells with high-energy x-rays (photons), gamma rays, or protons. It usually follows surgery. Radiation kills brain tumour cells that may remain in the area, following surgery. Sometimes, people who can't have surgery have radiotherapy instead. It may also be given in combination with chemotherapy. Overall, radiotherapy is required by 50% of **all** cancer patients. It is one of the most effective treatments for cancer.

Should I have radiotherapy?

Even if the tumour has been removed, radiotherapy can be recommended to keep unseen cells from growing. This should destroy left over cells and prevent a recurrence of growth. There is a suggestion that, several years after radiotherapy treatment, another brain tumour could develop because of this treatment. There is also a risk that healthy cells may die in the brain. This is called radiation necrosis. This is rare. But you should take all factors into consideration. Again, talk with your doctors, trust them and be guided by them. Radiotherapy will not be recommended if you only have a few dividing cells in your cancer. The therapy would not be very successful.

How does radiotherapy work?

Radiotherapy treatments take advantage of the fact that healthy tissue repairs damage in about 8 hours, so that regular low to moderate doses of radiation can be delivered daily. Diseased tissue cannot repair like this, so eventually the tumour cells die as they cannot reproduce effectively. The tumour then gets smaller. Treatment results, which are visible on follow-up scans, include shrinkage of the tumour or no further tumour growth. Because cell destruction is a



lengthy process, it can often take up to six months before the effect of treatment can be determined by doctors.

Radiation is measured in units called gray (Gy) or centigray (cGy) which is one hundredth of a gray. Depending on the type of radiotherapy being given, a patient may be given just one dose of radiation, or many doses over a period of weeks. This is called fractionated radiotherapy. The amount of overall dose and amount to be given each day will depend on the tumour type. The amount delivered to the brain is limited by how much radiation normal tissue can tolerate. From the experience of using radiotherapy, clinicians know how much dose brain tissue can cope with.

Fractionated radiotherapy

What is it?

Most patients diagnosed with a glioma receive fractionated radiotherapy. Fractionated radiotherapy is when the full dose of radiation is divided into a number of smaller doses called fractions. This allows healthy cells to recover between treatments. It is also called External Beam RadioTherapy (EBRT). Fractionated external beam radiotherapy (EBRT) is the most common method of radiotherapy used for people with brain tumours. A large machine outside of the body aims beams of radiation at the head. Because cancer cells may invade normal tissue around a tumour, the radiation may be aimed at the tumour and nearby brain tissue (called a margin), or at the entire brain. Some people will also need radiation aimed at the spinal cord. Fractionated radiotherapy is often given over a period of about 6 weeks and you will need to attend every day (except weekends). See 'How radiotherapy is given' (page 9).

Sometimes radiotherapy is given as a palliative, or supportive care, treatment. This is when radiotherapy is used to control the symptoms of your brain tumour, rather than try to treat the brain tumour. For example, a shorter course of radiotherapy can shrink the tumour which in turn will relieve symptoms of pressure such as headache, sickness and drowsiness. You still have radiotherapy to the brain as a course of daily treatment sessions called fractions, but how long the course lasts will vary. It is likely to be 1 to 2 weeks of daily treatments so a much shorter regimen. It may be given in conjunction with palliative treatment or when active treatment is no longer appropriate. You will be living with your brain tumour, and may do so for a long time, but you may need supportive care that helps you lead the life you want to lead. The focus here is on managing symptoms so that you can lead a good quality of life. Remember – palliative care is not end of life care. These are two very different stages and you can lead a good quality of life for a long time when receiving palliative care.

Types of fractionated radiotherapy

In the late 1990s conformal radiotherapy (CRT) was widely introduced. This provided an excellent way to shape the treatment to 'conform' to the shape of the target. It is a highly effective technique for reducing side effects, and continues to be in widespread use. In the UK, over the last 10 years, a development of this, known as intensity modulated radiotherapy (IMRT) has been introduced. This is particularly useful for patients whose tumours have a more challenging shape or position.

Intensity Modulated Radiotherapy (IMRT)

IMRT is a technique that allows even better shaping of the radiotherapy dose to the shape of the tumour and is particularly useful if the shape of the tumour is complex, with concave parts. This allows the high dose to be moved away from normal tissue structures more effectively in complex tumours than is possible with conformal radiotherapy. As well as considerations of normal tissue, IMRT is useful for producing an even dose through the tumour or for producing a variation in dose where it is intended to give different dose levels to different parts of the tumour.

IMRT is based on a combination of two technology features. The first is sophisticated computing. IMRT usually uses quite a large number of beams, usually at least 7 but even as many as 51, and each beam can be divided into multiple 'beamlets'. The computer can calculate how much dose to give in each beamlet in order to produce the dose distribution that is required. IMRT is often faster to plan and often faster to deliver than conformal therapy.

IMRT is appropriate for both benign and malignant tumours. The dose is varied to deliver higher, more effective doses to the tumour, which creates a 'hot spot' at the tumour site. It is like several torchlight beams being shone from different directions but at one spot. The light is most intense where the beams meet. But on its own, each beam is relatively weak and passes through normal tissue without much effect. It takes a bit longer to deliver because of the complexity, so about 15 to 45 minutes per treatment.

Image Guided Radiotherapy (IGRT)

Before the introduction of IMRT, radiation oncologists had to contend with variations in patient positioning and internal movement, such as breathing. Generally breathing in patients having treatment to their brain is not an issue as you wear a mask which keeps the head very stable. They manage these variations by treating a wider margin of the tumour. So, for example, to treat a golf ball sized tumour, they would use a tennis ball. With IGRT you can use a golf ball to treat a golf ball. IGRT gives high resolution, 3D images to pinpoint the tumour site, adjusting your position as necessary, and completes a treatment – all within the time slot.

This is usually done with some form of Xrays or an Xray based CT scan and there are different styles of IGRT in use. The use of this imaging allows for greater precision, and in turn this allows for reduction in the safety margin that is required to ensure effective coverage of the target.

The best value from IMRT comes if it is combined with image guidance and most modern radiotherapy machines are fully equipped with both technologies which can be used together.

Internal radiation therapy (implant radiation therapy or brachytherapy)

Internal radiation isn't commonly used for treating brain tumours and is under study. The radiation comes from radioactive material usually contained in very small implants called seeds. The seeds are placed inside the brain and give off radiation for months. They don't need to be removed once the radiation is gone.

How is fractionated radiotherapy given?

You have the fractions as a series of treatment sessions that make up your radiotherapy course. This means that the course of radiotherapy is usually given everyday, from Monday to Friday so you will need to attend your radiotherapy centre every day. Most patients are not treated at weekends, however some centres are now opening at weekends. The radiographers who plan your radiotherapy will arrange your appointments dates and times with you as soon as they can. They will try to find appointments to suit you. Because radiotherapy is complex and your treatment is planned individually for you, you will need to attend the cancer centre for at least one planning appointment before you start treatment. There will be a time delay between attending for your planning appointment(s) and your first treatment. This is so your personal treatment is calculated to ensure your tumour gets the correct dose, and the dose to tissues that do not need treatment get as low a dose as possible. This usually takes about 2–3 weeks. Ask your radiographers about your future dates when you attend your planning appointment. If you have had surgery, having a short period of time to recover before you start radiotherapy can be helpful.

Your radiation oncologist will discuss your case in the Multi Disciplinary Team (MDT) meetings. You will need to go to some planning sessions so that all the measurements can be taken. These are called simulations, when the mapping is done on a CT scanner to figure out how best to arrange the radiation beams and how best to protect the healthy tissue. If you are having radiotherapy, it is likely that you will need to wear a mask, made just for you, which is attached to the table to hold your head in place whilst you are receiving the treatment.

"To be honest, having the mask made was worse than the actual treatment for me. But it is only a moment. After this the whole thing was a breeze."

Patient, Southampton

The mask will enable you to breathe and see normally but it can feel claustrophobic. You only need to wear it for a few minutes at a time. If you are having whole brain radiotherapy (for secondary brain tumours) you may not need a mask.

You will be positioned carefully on a table and the mask fitted. Powerful and precisely placed radiation beams are directed at the tumour using a sophisticated device called a medical linear accelerator (linac). This rotates around you, delivering beams from different angles. When these beams converge on your tumour, the effect is very powerful. It is not painful but you will need to keep still. You may be able to talk to the radiographer who will keep a close eye on you from the next room.

Side effects of fractionated radiotherapy

During your treatment, you should only use fragance free and mild soap. So nothing on your hair like gel, or colouring. E45 cream is an excellent moisturizer to use on your skin, which may become burnt.

You will probably not feel any side effects for at least two weeks. Then in week three the following starts to happen:

Hair loss – Not everyone will lose their hair. For example, patients with pituitary tumours may not lose their hair. If there is hair loss, it is gradual. It thins and then becomes patchy, usually where the beam leaves your head. Apart from affecting appearance, it makes you notice change in temperatures. It will often grow back; it might have a different texture but you won't be bald forever.

Thrush – if the beam is near your mouth you may find that it becomes sore. Tell your nurse, who can provide things to alleviate this.

Nausea – you may be sick or feel sick, particularly if the beam is catching your ear. Again, don't suffer in silence. Anti-sickness medication will bring relief.

Skin irritation – your scalp may become red, dry and tender. Apply moisturizers at any time during your treatment; it is important that you don't use thick layers. Your health care team can suggest ways to relieve these problems.

Ear congestion – if the beam is passing through your ear, this will become dry and then irritated towards the end and beyond your treatment. You may find that your ear is 'leaking'. Again, see your doctor who will provide eardrops.

Fatigue – it is important to stay active. Some people continue to work. However, you must rest when you need to.

"People warned me that 4 to 6 weeks AFTER the treatment has finished I would feel really tired. This lasted about a month; having a shower was a supreme effort and I had to lie down afterwards. A course of radiotherapy is the equivalent as having another round of major surgery. Listen to your body."

Patient, Leeds

Brain swelling – sometimes, but not often, radiotherapy causes brain tissue to swell. You may get a headache or feel pressure. Your health care team will watch for signs of this problem. They can provide medicine to reduce the discomfort. Radiation sometimes kills healthy brain tissue. Although rare, this side effect can cause headaches, nausea and seizures. Call your doctor immediately if you experience any symptoms which are new or different.

Weight loss – you may lose weight. This is probably the only time when you will be told it is OK to eat foods which are high in fat. Eat a little and often.

Late effects – there is increasing evidence that radiation to large part of normal brain (whole brain radiotherapy (WBRT)) causes effects years after treatment, called late effects. These effects can include impairment in memory, concentration, and higher mental functions. This is the reason why wherever possible focused treatment, particularly radiosurgery (see below), is increasingly used instead.

Stereotactic radiotherapy (SRT or FSRT)

What is it?

The term ‘stereotactic’ refers to accurate location in space. Stereotactic radiotherapy is a modern version of fractionated radiotherapy, delivered in a number of fractions. As the targeting is better than conventional radiotherapy (described in the previous section), it is usually delivered in a small number of sessions, spanning several days or even a few weeks. How many fractions or daily treatments will depend on the tumour type and fitness of the patient.

Stereotactic radiosurgery (SRS)

What is it?

This is another form of treatment with radiation, where the radiation dose is given in one single session, on one day. It is used for small tumours, usually much smaller than 4cm diameter, that are well contained. It is not suitable for large, more diffuse tumours, that are better treated with one of the fractionated techniques (radiotherapy or SRT). However it is suitable for many small tumours (e.g. cancer metastases), all being treated usually in the same session. For this is the highest degree of precision is needed, thus usually a rigid frame is used to aid the targeting (see under Gamma Knife).

What are the differences between Gamma Knife and CyberKnife?

You may also hear radiosurgery being referred to as Gamma Knife (GK), which delivers a focused dose to the tumour, and a limited dose of radiation outside the tumour area. There are other treatment machines that can offer the treatment, such as CyberKnife (CK) and

linac based X-knife. These terms for treatment machines are the commercial names, like Hoover is for vacuum cleaners.

There are some differences between the two. The CyberKnife is not specific to brain tumours whereas the Gamma Knife specifically treats cancer and other diseases of the brain, head and neck. The CyberKnife is a low energy linear accelerator and does not require you to be placed in a frame fixed to the skull, but a rigid mask, as in radiotherapy. The Gamma Knife uses 3D information from MRIs and CTs to provide treatment, and for the exquisite precision the frame is used. There is an overlap between their uses, as some doctors use CyberKnife (CK) for SRS and the Gamma Knife can also be used for SRT. But on the whole, on a CK you are likely to be treated in several sessions while on the GK it is likely to be a one-day treatment.

How is Gamma Knife delivered?

The Gamma Knife consists primarily of a metal helmet, shaped to hold the head still, whilst many beams of radiation can be directed to focus on a particular point (the 'target' or 'isocentre') in the head. The specific target in the head is imaged via an MRI scanner (and if a vascular lesion, also an angiography machine), and then entered into a planning system. This provides the necessary x, y and z co-ordinates so that the beams can all be focused to the right area. The treatment is then planned to calculate the best ways of delivering radiation to the target area, with minimal radiation to nearby areas. The beams coincide at the fixed focal point of the tumour or lesion. Each beam will contribute a small dose of radiation and have a minimum impact on the tissue on its way to the target. However, when all the beams meet at the target point, the resulting dose has the effect of destroying the tumour. The treatment planning software can deal with irregular shaped tumours. An average procedure takes from 1–2 hours. The treatment is done as an outpatient and is usually over in half a day.

Which patients can radiosurgery benefit?

Due to its power and accuracy radiosurgery can give clinicians the ability to treat patients with cancers once considered untreatable and those for whom surgery is not an option, such as tumours deep in the brain.

Of the 120+ different types of brain tumour that people can contract, you are most likely to have radiosurgery if you have an acoustic neuroma or a meningioma that is less than 4cm across. Radiosurgery can also be used for other brain tumours, including small secondary brain tumours, and for people who can't have brain surgery due to other medical conditions. It is also used for haemangioblastomas that couldn't be removed, or were only partially removed, or came back after surgery.

Specialists don't recommend radiosurgery for larger brain tumours. It isn't possible to get the same dose of radiotherapy throughout the treatment area with a large brain tumour. However, radiosurgery is suitable to treat many small metastases, because even in the same sitting several 'shots' can be delivered to treat each brain tumour throughout the brain. In this circumstance traditional radiotherapy is only able to deliver a radiation dose across the whole brain and this then becomes a one off procedure that would not allow for further treatment of recurring tumours. On the other hand radiosurgery is able to specifically target these tumours in the brain and due to its accuracy and low dosage distribution this treatment can be repeated if required. When a cancer patient has control of the underlying disease but is confronted with a small tumour in the brain, the ability to deal with the tumour efficiently and the knowledge that this can be repeated has large implications for quality of life.

Radiosurgery may also not be suitable if there are certain nerves running through the treatment area. The nerves could be given too much radiation. This could cause problems such as hearing loss, depending on the role of the affected nerves.

There are a number of benefits of this treatment. It involves minimal damage, so you can have it done as an outpatient, with the treatment usually lasting less than half a day. There should be limited side effects as radiosurgery spares healthy tissue that surrounds the targeted area. This means that other healthy areas in the brain receive little radiation so there are fewer complications and faster recovery times, compared to conventional surgery and radiotherapy. But remember it can only be used to treat tumours that measure less than 4cm and which are well defined.

Don’t be misled by the words surgery and knife. There is no invasive surgery, so no knife.

Radiosurgery is also shown to be beneficial for the treatment of non-cancerous conditions. In addition, also tackles acoustic neuromas and other benign tumours, and trigeminal neuralgia (a functional disorder).

Side effects of radiosurgery

The treatment day can be tiring but the only side effect is likely to be a heavy pressure headache once the frame has been removed and possibly some minor bleeding from where the frame has been. Over the following weeks, some patients experience headaches, dizziness and nausea. However, no patient usually experiences these for more than 2–3 weeks and many patients experience no side effects at all.

The SRS procedure means that follow up and regular scans at the 3, 6 and 12 month periods allows your consultant to see the effectiveness of the treatment.

> *"When having Gamma Knife treatment, the frame is held by screws. Once the frame was on I did get the most excruciating pressure headache. However I had a very switched on nurse, who gave me IV paracetamol and within 15 minutes the pain lifted. I felt great, hungry and ready to eat! I know everyone is different, but I suggest strike when the iron's hot and avoid any pain if possible. It's also a cliche, but to remain positive does make a difference. It's hard, but I came through a more resilient human being."*

Patient, London

Accessing radiosurgery

Your consultant will discuss your treatment options with you. They will explain which type of treatment would be best for your condition. If it is thought that radiosurgery is the optimal treatment for you then you will be referred to a centre where radiosurgery is carried out.

Proton beam therapy

More detailed comprehensive information can be found at brainstrust.org.uk/brain-tumour-support/resources/downloads

What is it?

The source of radiation is protons rather than x-rays (photons). This is a type of particle therapy which uses a beam of protons to irradiate the tumour. The proton beam is aimed at the tumour. The dose of radiation to normal tissue from a proton beam is less than the dose from an x-ray beam. All protons of a given energy have a certain range; no proton penetrates beyond that distance, so this treatment is appropriate in cases where there is a need for the radiation dose to fall off to zero after it hits the target. In conformal therapy there is exit radiation beyond the tumour, which is why you may lose some hair on the side where the beam leaves your head, but proton beams slow down and stop within the target. Proton beam therapy is expensive. Currently there is one proton beam therapy centre at The Christie, Manchester. A second centre is due to open in London in 2020. Patients now benefit from being treated in the UK.

Which patients can benefit from proton beam therapy?

Like SRT/SRS, this treatment is only appropriate for certain types of tumour and people. It is used most often to treat brain tumours in young children whose brains are still developing. Proton beam therapy can also be used to treat adult cancers where the cancer has developed near a place in the body where damage would cause serious complications, such as the optic nerve. These types of cancer make up a very small proportion of all cancer diagnoses. Even if there was unlimited access to proton beam therapy, its use would not be recommended in most cases.

Cancer Research UK estimates that only one in 100 people with cancer would be suitable for proton beam therapy.

Is it effective?

It is important to know that Proton Beam treatment has never been compared with modern SRS or event SRT, so it may not be 'better' than the techniques detailed in the previous chapters. We cannot even say that proton beam therapy is 'better' overall than radiotherapy. At the moment there isn't the research evidence to say whether proton beam therapy is a more effective treatment than conventional radiotherapy. Proton beam therapy may cause less damage to healthy tissue, but it is still unclear whether it is as good at destroying cancerous tissue as conventional radiotherapy. At the same time we have ample evidence that SRS and SRT protects adjacent normal tissue.

As proton beam therapy is usually reserved for very rare types of cancer, it is hard to gather systematic evidence about its effectiveness when compared to radiotherapy.

People who travel abroad from the UK to receive proton beam therapy usually respond well. But these people have been specifically selected for treatment as they were seen as 'optimal candidates' who would benefit the most. Whether this benefit would apply to more people with cancer is unclear.

Useful resources and links

Radiotherapy

brainstrust.org.uk/therapies

www.cancerresearchuk.org/about-cancer/cancers-in-general/treatment/radiotherapy

www.cancerresearchuk.org/about-cancer/brain-tumours/treatment/radiotherapy

www.nhs.uk/conditions/radiotherapy

www.macmillan.org.uk/information-and-support/treating/radiotherapy/radiotherapy-explained

Advances in radiotherapy

www.bmj.com/content/345/bmj.e7765.long

Proton Beam Therapy

brainstrust.org.uk/brain-tumour-support/resources/downloads
Nine easy, downloadable guides that cover every aspect of proton beam therapy.

Cancer Research UK: PBT science blog July 2015 – 'Proton beam therapy: where are we now?'

scienceblog.cancerresearchuk.org/2015/07/16/proton-beam-therapy-where-are-we-now/
This article provides an excellent overview of the current situation of the development of the national PBT programme.

References about PBT

NHS choices: Proton Beam Therapy – 'What is proton beam therapy?'
www.nhs.uk/news/2014/09september/Pages/what-is-proton-beam-therapy/
This article provides a good starting point describing what PBT is and how it works.

NHS centres receiving PBT facilites

University College London Hospital NHS Foundation Trust Proton Beam Therapy webpage
www.uclh.nhs.uk/aboutus/NewDev/NCF/PBT/Pages/Home.aspx

The Christie NHS Foundation Trust Proton Beam Therapy webpage
www.christie.nhs.uk/our-future/our-developments/protons/proton-beam-therapy.aspx

Together, UCLH and The Christie will see more children and teenagers with cancer than almost any other centre in the world, and more adults with brain cancers than any other centre in the UK.

Reviews on PBT

Crellin AM & Burnet NG. Proton Beam Therapy: The Context, Future Direction and Challenges Become Clearer. Editorial. *Clin Oncol (R Coll Radiol)*. 2014; 26: 736-738.
www.sciencedirect.com/science/article/pii/S0936655514003835
This review highlights the challenges of developing a national PBT facility and strategies to help the UK to contribute to PBT research.

Jones B, Burnet N. Radiotherapy for the future. Protons and ions hold much promise. BMJ 2005; 330(7498): 979-80.
www.ncbi.nlm.nih.gov/pmc/articles/PMC557134/
This editorial highlights the potential impact of a proton service to patients with hard to treat tumours.

Radiotherapy research and clinical trials

www.nhs.uk/Conditions/Radiotherapy/Pages/clinical-trial.aspx

ctrad.ncri.org.uk/

De Ruysscher D, Mark Lodge M, Jones B, Brada M, Munro A, Jefferson T, PijlsJohannesma M. Charged particles in radiotherapy: a 5-year update of a systematic review. *Radiother Oncol*. 2012 Apr; 103(1): 5-7.
www.sciencedirect.com/science/article/pii/S0167814012000060
This review highlights the importance of a coordinated research effort through clinical trials to investigate the role of protons and to provide robust clinical data.

Glossary

Here are some definitions of words that you may come across during your treatment. You won't hear all of them; many will not be relevant to you. For a more comprehensive glossary visit:

brainstrust.org.uk/glossary

General words

Word	Definition
Adjuvant	Usually used as 'adjuvant therapies'. These are treatments which are added to increase effect e.g. radiotherapy, chemotherapy.
Asymptomatic	If you are asymptomatic it means you don't have any symptoms.
Benign	Not threatening to health, unlikely to recur and is not progressive.
Biopsy	A medical test performed by a surgeon or an interventional radiologist who will take a sample of cells or tissues for examination.
Blood brain barrier (BBB)	A barrier between brain tissue and circulating blood. It is there to protect the brain and prevents substances from leaving the blood and crossing into the brain tissues.
CSF (cerebrospinal fluid)	A watery fluid that is continuously produced and absorbed and that flows in the ventricles within the brain and around the surface of the brain and spinal cord.
Chemotherapy	Drug therapy for cancer.
Clinical presentation	The picture of signs and symptoms, which leads to a diagnosis.

Word	Definition
Concurrent	Happening at the same time. Radiotherapy and chemotherapy are often referred to as concurrent when they are given at the same time.
Concomitant	Naturally accompanying or follows something
End of life	A phrase used to describe a phase of illness which has become advanced, progressive and incurable.
First line management	Initial treatment of an illness.
Grade	A brain tumour will be given a grade which refers to the way the cells of the tumour look under a microscope. Grade 1 (low grade) refers to tumours that appear less likely to spread and grade IV (high grade) refer to tumours that appear to grow more quickly, or are most malignant. The brain tumour will be graded according to the highest grade of cell that the pathologist sees in the biopsy specimen. So if the tumour has a high percentage of grade II cells, and a small percentage of grade III cells, the tumour will be graded as a grade III.
Histology	The study of tumour cells under a microscope.
Histopathology	The study of diseased tissues at a minute (microscopic) level.
Imaging	The use of technology to create a picture of the brain e.g. MRI scan.

Word	Definition
Immunohistochemistry (IHC)	The process of detecting antigens or biological markers within tumours or brain tissue using antibodies. Immunohistochemistry provides insight about the classification of brain tumours by identifying cellular markers of phenotype and about the tumour's potential to grow.
Intracranial	Inside the cranium.
Intracranial pressure (ICP)	Pressure inside the cranium, caused by pressure of the subarachnoidal fluid.
Laterality	The side of the body in which symptoms are showing.
Localised	Confined or restricted to an area.
Malignant	Cancerous, tending to invade normal tissue or to recur after removal.
Markers	Pathologists can test for markers in the tumour tissue. Markers can be genetic, molecular or immunohistochemistry. These tests can: – aid the diagnosis of brain tumours which are sometimes hard to diagnose – allow clinicians to work out a prognosis – indicate whether a tumour will respond to a specific type of treatment.
MDT	Multidisciplinary team meeting.
Metastatic brain tumour	A secondary brain tumour formed of cancer cells that began elsewhere in the body e.g. lung, breast, colon, kidney, skin.

Word	Definition
MRI (magnetic resonance imaging)	A special radiology technique which takes pictures of internal structures of the body using magnetism, radio waves, and a computer to produce the images of body structures.
Microvascular proliferation	Abnormally thickened blood vessels which tend to be seen in higher grade gliomas. They tend to be leaky and cause contrast enhancement on imaging.
Modality	A method of treatment.
Morphology	The form and structure e.g. of a tumour.
Neuro-oncology	The branch of medical science dealing with tumours of the nervous system.
Neuropathology	The study of diseases of the nervous system, which includes the brain.
Optimal	Most desirable or satisfactory.
Overall survival (OS)	The percentage of people in a study or treatment group who are still alive for a certain period of time after they were diagnosed with or started treatment for a disease.
Palliative	Therapy with the goal of relieving symptoms and improving quality of life.
Pathology	The branch of medicine that looks at abnormal changes in cells and tissues which signal disease.
Prognosis	A forecast as to likely outcome, the chance of recovery.
Progression free survival (PFS)	The length of time during and after the treatment of a disease that a patient lives with the disease but it does not get worse.

Word	Definition
Proliferation	An increase in the number of cells as a result of cell growth and division.
Prophylaxis	Preventative.
Radiotherapy	A treatment in which high-energy rays are used to damage cancer cells and stop them from growing and dividing.
Regime	A regulated system of treatment.
Systemic	Affecting or circulating throughout the body.
WHO classification	The World Health Organisation (WHO) classification for the grading of brain tumours.

Anatomy

For more information on brain anatomy look here:
brainstrust.org.uk/anatomy-tumour-types

Word	Definition
Axial (intra and extra)	Axial is the position as it relates to the central nervous system (CNS). Intra-axial is within the CNS; extra-axial is outside the CNS.
Anterior	Front.
Brain stem	The bottom portion of the brain, which connects the cerebrum to the spinal chord.
Cerebellum	The second largest structure of the brain, the cerebellum is located just above the neck in the back of the head.
Cerebrum	The largest area of the brain, which occupies the uppermost part of the skull. It consists of two halves (hemispheres).
Corpus Callosum	Nerve fibres that pass through and connect the two halves of cerebral hemispheres.
Cranium	The top portion of the skull.
Dura	The outermost of the three meninges.
Endocrine system	The tissues or glands in the body that secrete hormones.
Hypothalamus	The region of the brain that forms part of the wall of the third ventricle. It is part of the endocrine system.
Infra-tentorial	Below the tentorium.
Lobe	One of four sections of the cerebral hemispheres.

Word	Definition
Meninges	A membrane (one of 3) that envelops the brain and spinal cord).
Midline	An imaginary line running along the surface of the brain (front to back), which separates the right and left hemispheres.
Occipital lobe	The lobe of the cerebral hemispheres at the back of the head, just above the neck.
Parietal lobe	One of the four lobes of the cerebral hemisphere.
Posterior	Back.
Saggital	The front to rear plane of the body (chest to back).
Subcortical	The region of the brain below the cortex.
Supra-tentorial	Above the tentorium.
Temporal lobe	One of the four lobes of the cerebral hemisphere.
Tentorium	A flap of the meninges separating the cerebral hemispheres from the brain structures.
Thalamus	The area surrounding the third ventricle.
Ventricles	Four connected cavities in the brain through which cerebrospinal fluid flows.

Imaging

The use of technology to create a picture of the brain e.g. MRI scan

Word	Definition
Anterior	Placed before or in front.
Artifact	Fuzziness or distortion in an image caused by manipulation, such as file compression.
Axial	Perpendicular to the long axis of the body.
Calcification	Calcium deposits in soft brain tissue.
CT (computerised tomography)	X rays are aimed at slices of the body (by rotating equipment) and the results are assembled with a computer to give a three-dimensional picture of a structure.
Contrast	Sometimes a contrast dye is injected during an MRI scan. The dye helps the radiologist see certain areas more clearly. It helps show what is normal tissue and what could be a lesion.
Coronal	The plane created by an imaginary line that divides the body at any level into anterior and posterior portions. Also called the *frontal plane*.
Cortex	The outer layer of the brain.
Cortical mapping	Cortical maps identify the language, motor, and sensory areas of the cortex and are often used during brain surgery.
Craniocaudal	The direction of entry of the x-ray beam. The beam enters at the cranial end of the part being examined and exits at the caudal end.
Cyst	Brain cysts are called neoplasms and are made up from natural brain matter, or they may represent more serious problems in the brain that need the attention of a neurologist.

Word	Definition
Delineation	The outline of the tumour. Also used to delineate target volume of tumour for surgery and radiotherapy.
DTI (diffusion tensor imaging)	A refinement of magnetic resonance imaging (MRI) that allows the doctor to measure the flow of water and track the pathways of white matter in the brain. DTI is able to detect abnormalities in the brain that do not show up on standard MRI scans.
EEG (electroencephalogram)	A record of the tiny electrical impulses produced by the brain's activity. By measuring characteristic wave patterns, the EEG can help diagnose certain conditions of the brain.
Eloquent	Used to describe an area of the brain where, if it is damaged or removed, will result in loss of sensory processing or linguistic ability.
Enhancement	A substance is used to enhance the structures within the brain during a scan. This reduces the lowest grey values to black and the highest to white.
Fibrillary	Made up of minute fibres.
FLAIR (Fluid attenuated inversion recovery)	A pulse sequence used in scanning to null signal from fluids. For example, it can be used in brain imaging to suppress cerebrospinal fluid (CSF).
fMRI (functional MRI)	Functional MRI takes the map obtained with traditional MRI imaging, and adds on additional dimensions, such as measuring regional blood flow over time, or something about the biochemistry of tissue of a brain tumour in a specified location in the brain.
Focal	Limited to a specific area.

Word	Definition
Foci	Foci is the plural of focus. It suggests microscopic visualisation of the tumor cells. Under a microscope therefore you might see more than one indication of one or two microscopic foci of possible invasion.
Gadolinium	A substance that enhances tumour images using magnetic resonance imaging (MRI).
Heterogeneous	A state of having different characteristics and qualities.
Homogeneous	Of a uniform, consistent nature.
Hydrocephalus	An abnormal buildup of cerebrospinal fluid (CSF) in the ventricles of the brain.
Hyperostosis	An excessive growth of bone.
iMRI	The use of high-resolution intraoperative magnetic resonance imaging (iMRI) to clearly see brain tumors while performing surgery.
Increased (high) signal	Hyperintensity signals show up as increased brightness (white) on MRI using different scanning techniques. The nature of brain scans causes tissues with more water to give off brighter signals that appear whiter on the scans.
Inflammation	Swollen brain tissue.
Intrinsic	Originating from, or situated within, an organ or tissue.
Isotope	A form of a chemical element that has a different-from-normal atomic mass. Isotopes are used in a number of medical tests because they can produce images of tissues that can be used to detect diseases or conditions.

Word	Definition
Lesion	A brain lesion describes damage or destruction to any part of the brain. It may be due to trauma or any other disease that can cause inflammation, malfunction, or destruction of a brain cells or brain tissue.
Margin	1. A border or edge of the tumour. 2. In surgery, margin refers to an amount that is allowed but that is beyond what is needed. So the margin taken around the tumour.
Metabolism	The chemical and physical processes that happen to maintain the body and produce energy.
Midline	An imaginary line running along the surface of the brain (front to back), which separates the right and left hemispheres.
Motor	Movement, control of muscles.
Metastasis/metastases	Spread to another part of the body, usually through blood vessels, lymph channels or spinal fluid.
MRI (magnetic resonance imaging)	A special radiology technique which takes pictures of internal structures of the body using magnetism, radio waves, and a computer to produce the images of body structures.
Multifocal	Having many focal points. Damage caused by the disease occurs at multiple sites.
Neoplasm	A tumour, either benign or malignant.
Oedema	Swelling caused by fluid.
Perfusion MR	A special type of MRI that uses an injected dye in order to see blood flow through tissues.

Word	Definition
PET (position emission topography)	A scanning device which uses low dose radioactive sugar to measure brain activity.
Posterior	Back.
Pseudoprogression	Swelling or contrast enhancement on a scan which suggests tumour progression or recurrence, when it is treatment effect. Pseudoprogression can stabilise without additional treatments and often remains clinically asymptomatic.
Saggital	The front to rear plane of the body (chest to back).
Signal	Brightness of a tissue or structure on MRI.
SPECT (single photon emission computed tomography)	A scanning technique which uses radioactive materials.
Subcortical	The region of the brain below the cortex.
T1 weighting	MRI image showing structures; cerebrospinal fluid appears black on the image.
T2 weighting	MRI image showing water; oedema and cerebrospinal fluid appear white on the image.
Vascularity	The blood supply of a tumour.

Radiotherapy

Word	Definition
cGy (centiGrays)	A unit of absorbed radiation dose equal to one hundredth.
Conformal	Radiotherapy beams are shaped in three dimensions to match the shape of the tumour.
CyberKnife®	Brand name of a machine used to deliver linear accelerator stereotactic radiosurgery.
Demyelination	Loss of the myelin sheath of a nerve.
Dose	The total amount of ionizing radiation absorbed by material or tissues, expressed in centigrays.
Dose rate	The quantity of a treatment given over a period of time.
External Beam	Radiation therapy that uses a machine to aim high energy rays at a brain tumour.
Fractionated	Dividing the total dose of radiation to be given into several smaller, equal portions delivered over a period of days.
Gamma Knife®	Brand name of a machine used to deliver stereotactic radiosurgery (SRS), a focal form of radiation therapy.
IMRT (intensity modulated radiation therapy)	Specialised equipment that shapes radiation beams to the size and shape of the tumour.
Late effects	A health problem that occurs months or years after a disease is diagnosed or after treatment has ended.

Word	Definition
LINAC (linear accelerator)	An electrical device that creates ionising radiation in the form of x-rays (photons).
Mask	A mould to keep your head from moving so that you are in the exact same position for each treatment.
Necrosis	Dead cells.
Palliative radiation	Radiation therapy with a goal of relieving symptoms and improving quality of life.
Proton beam	A treatment that uses high energy beams to treat tumours.
Radiation oncology	The use of radioactive substances and x-rays for the treatment of brain tumours.
Radiosurgery	A special form of radiation therapy that uses a large number of narrow, precisely aimed, high dose beams of ionising radiation.
Stereotactic radiosurgery (SRS)	A form of radiation therapy that focuses high-powered x-rays on a small area of the body, better targeting the abnormal area. It is a treatment, not a surgical procedure. Some types of stereotactic radiosurgery require a specially fitted face mask or a frame attached to your scalp. **Other names:** Gamma Knife; CyberKnife; Stereotactic radiotherapy; SRT; Stereotactic body radiotherapy; SBRT; Fractionated stereotactic radiotherapy.
Toxicity	State of being poisonous.
Tumour progression	When a tumour recurs, or begins to grow again. The second stage of tumour development.
WBRT (whole brain radiotherapy)	A type of external beam radiotherapy which is given to the whole brain over a period of weeks.

Resources used

Patient/carer representative

Clinical specialist radiographer

Radiation oncologist – neurooncology

Consultant neurosurgeon

Consultant neuropathologist

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Production of *brainstrust*'s information is supported by the Anna Horrell fund. Anna, wife and mum, tragically passed away in August 2017 after a valiant fight against a glioblastoma. Throughout her life and her illness, she was an inspiration to us all, fighting bravely and cheerfully in the face of adversity. She was the beating heart of our family, and her loss left a hole in our lives that can never be replaced. In her incredible memory, we are passionate about helping others diagnosed with a brain tumour to navigate this most difficult of journeys.

Mike, Tom, Rebecca, Charlie & Sophie

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brainstrust is a registered charity in England and Wales (1114634), and Scotland (SC044642)
Date published: January 2016
Last edited: December 2015
Due for review: January 2022